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WINTER MORTALITY OF THE RUSSIAN WHEAT APHID (HOMOPTERA: APHIDIDAE) ON RANGE GRASSES IN NORTHERN UTAH

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The Russian wheat aphid, *Diuraphis noxia* (Mordvilko), is a newly established pest of small grains in western North America (Stoetzel 1987). This aphid also feeds on several native and introduced grasses, including grasses that are widely planted for forage improvement or erosion prevention in rangelands (Kindler and Springer 1989, Kindler et al. 1991). Recent attention has focused on the potential importance of these grasses as "oversummering" hosts for *D. noxia*, i.e., as sources of aphid populations between the summer harvest and fall sowing of winter wheat, *Triticum aestivum* L. (Clement et al. 1990, Armstrong et al. 1991). Comparatively little information is available on the role of grasses as overwintering sites, even though migrants from noncrop hosts could cause extensive damage to cereals in the spring. In this study I investigated the overwintering success of the Russian wheat aphid on cool-season grasses in northern Utah.

The ability of *D. noxia* to survive winter conditions varies regionally in North America. Winter mortality may reach 100% at higher latitudes (Butts 1992), so that aphid populations must be reestablished by migrants each season. Such high mortality may stem from a lack of sexual reproduction (anholocycly) in North American populations (Kiriac et al. 1990, Stoetzel and Hammon 1992), since a sexual generation in the fall is needed to produce the cold-hardy egg stage. Parthenogenetic females of *D. noxia* are quite cold-hardy (Harvey and Martin 1988), however, and occasionally survive winter conditions in northern regions, including Colorado, Idaho, and Alberta (Butts 1992, Feng et al. 1992, Hammon and Peairs 1992).

The overwintering success of *D. noxia* in northern Utah has not been investigated, but the typical absence of aphids in early spring suggests that fall populations are eliminated during most winters. In October 1991 I detected a population of *D. noxia* on cool-season grasses in an experimental garden near Utah State University. I surveyed this population throughout the winter and compared the pattern of mortality with local temperature data.

Materials and Methods

A common garden of six native and introduced grass species (Table 1, nomenclature follows Barkworth and Dewey 1985) was established in 1990 at the Greenville Experimental Farm in North Logan, Utah. The garden consisted of 432 plants in six blocks, with 12 plants per grass species per block. All plants had produced flowering culms and large tussocks by early October 1991, at which time damage caused by the Russian wheat aphid (e.g., necrotic streaks on leaves) became apparent on several individuals. Further inspection confirmed the presence of Russian wheat aphids within the tightly rolled leaves of the newly produced fall (overwintering) tillers.

I estimated the initial extent of the aphid infestation on 15 October 1991 by collecting five tillers from each of 18 randomly chosen plants per grass species. Samples were transported to the laboratory in plastic bags and maintained at 5°C for later examination. I recorded aphid density as 0, 1–100, or >100 individuals per five tillers. I also noted any winged (alate) adults or nymphs bearing wing pads. Thirty-six of the original 108 plants (6

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TABLE 1. Number of plants from six grass species bearing 0, 1–100, or >100 *D. noxia* aphids per five tillers in October 1992.

Host species (cultivar)	Aphid density class 0	1–100	>100
Agropyron desertorum (Fischer ex Link) Schultes (crested wheatgrass, 'Nordan')	5	11	2
Elymus lanceolatus (Scribner & J. G. Smith) Gould (Snake River wheatgrass, 'Secar')	8	10	0
Leymus cinereus (Scribner & Merrill) A. Löve (Great Basin wildrye, 'Magnar')	7	11	0
Oryzopsis hymenoides (Roemer & Schultes) Ricker (Indian ricegrass, 'Paloma')	1	16	1
Pseudoregneria spicata (Pursh) A. Löve (bluebunch wheatgrass, 'Whitmar')	11	7	0
Thinopyrum intermedium (Schur) Barkw. & D. R. Dewey (intermediate pubescent wheatgrass, 'Luna')	5	12	1

per grass species) were then chosen for monthly samples from November 1991 to April 1992 (dates are listed in Table 2). On each sampling date I clipped 10–20 tillers per plant, sometimes after brushing away snowcover. In the laboratory I recorded the presence of any live aphids, which were so determined by the retention of a pale green body color and the independent movement of one or more appendages. A wider sample of plants was obtained on 8 and 21 April 1992; I pooled tillers from ≥ 10 individual plants per grass species so as to fill two 4-L plastic bags.

Daily temperature data from October to April were supplied by the Utah Climate Center, which maintains a weather station at Greenville Farm. To estimate the severity of winter conditions during the sampling period, I compared 1991–92 temperature records on the Utah State University campus (which is <2.5 km from Greenville Farm) with long-term (30-yr) averages from the same site.

RESULTS

The initial census in October indicated that aphids had infested all six species of cool-season grasses, with a few plants bearing >100 aphids per five tillers (Table 1). The proportion of plants infested varied significantly among grass species ($X^2 = 11.0$, df = 5, $P < .02$); virtually all of the Indian ricegrass plant bore aphids, while Russian wheat aphids were found on less than half of the bluebunch wheatgrass plants. Alate adults were found on only 5 of 108 plants, but nymphs bearing wing pads were common on all host species. Prior to this initial census, daily minimum temperature had dropped below freezing (down to −1°C) on only a single date (Fig. 1).

Live aphids remained abundant on each grass species on 19 November (Table 2), despite several days of sub-zero minimum temperatures in late October and early November (including a reading of −16°C on 3 November). On 6 December, 5 days after the minimum temperature had dropped to −20°C, each sample contained many dead aphids, but at least a few live aphids were found on all hosts except Indian ricegrass. No winged adults were found on this date or on any subsequent date.

Four hosts bore live aphids in early January, but only two (crested wheatgrass and intermediate pubescent wheatgrass) still did so by mid-February (Table 2). Very cold temperatures were recorded between these two sampling dates, including a seasonal low of −26°C on 21 January (Fig. 1). Most live aphids in the mid-February samples appeared to be in a torpid condition and were unable to right themselves or walk normally. Ten aphids that appeared to walk normally were placed on winter wheat seelings ('Hansel' variety) at room temperature (these seedlings were known to support a thriving laboratory colony of *D. noxia*). Although a few aphids probed the leaves and assumed a feeding stance, all were dead within 48 h.

Daily maximum and minimum temperatures were unseasonably high after the February samples were taken, and temperatures remained high throughout the early spring (Fig. 1). Despite this apparent improvement in

TABLE 2. Presence (+) or absence (−) of live *D. noxia* aphids from six grasses sampled from November 1991 to April 1992.

Host[a]	19 Nov	6 Dec	3 Jan	11 Feb	11 Mar	2 Apr	8 Apr	21 Apr
Crested wheatgrass	+	+	+	+	+	−	−	−
Snake River wheatgrass	+	+	−	−	−	−	−	−
Great Basin wildrye	+	+	+	−	−	−	−	−
Indian ricegrass	+	−	−	−	−	−	−	−
Bluebunch wheatgrass	+	+	+	−	−	−	−	−
Intermediate pubescent wheatgrass	+	+	+	+	−	−	−	−

[a]Full descriptions in Table 1.

ambient temperature, only crested wheatgrass bore live aphids by mid-March, and no live aphids were found on any host in early April (Table 1). This local extinction was confirmed by the more widespread surveys on 8 and 21 April, and no aphids were observed during experiments in the garden from May to July 1992. Monthly averages of daily minimum temperatures in 1991–92 suggested that the extinction of the aphid population occurred during a fairly typical winter. Average temperatures from November to January were only slightly below long-term averages, and the period from February to April (which included the last dates when live aphids were observed) was significantly warmer than usual (Table 3).

DISCUSSION

This survey suggests that parthenogenetic Russian wheat aphids cannot survive typical winter temperatures in northern Utah. Nevertheless, aphids may survive winters that are warmer than usual, as low numbers of live aphids were recovered as late as mid-March in 1992. A small fraction of an aphid population on wheat did survive winter conditions in 1989–90 (but not 1988–89) in southern Alberta, where temperatures are generally colder than those in northern Utah (Butts 1992). Similarly, aphids apparently persisted through the winter of 1987–88 in southwestern Idaho but were not detected after mid-December in the colder, early winter of 1988–89 (Feng et al. 1992). Further research is needed to assess how other abiotic factors (e.g., snowcover or humidity) may modify the effect of temperature on aphid survival.

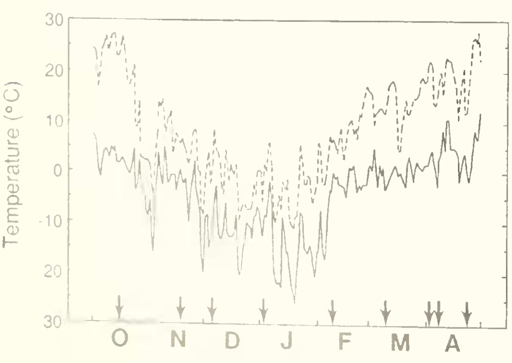

Fig. 1. Daily maximum and minimum temperatures, October 1991–April 1992 at Greenville Farm. Arrows indicate dates when grasses were sampled for aphids.

The overwintering success of *D. noxia* on cool-season grasses may also depend on host species. The temporal pattern of mortality in 1991–92 appeared to reflect the differing growth forms of the six hosts in the experimental garden. Indian ricegrass yielded no live aphids as early as 6 December, even though this host bore the most widespread infestation in October (Tables 1, 2). Because Indian ricegrass produces very thin shoots that are arranged in a sparse, open tussock, it is expected to render little protection to aphids beyond that provided by the individual rolled leaf. In contrast, the extremely dense, compact tussocks of crested wheatgrass should provide a substantial buffer from either cold injury or desiccation, and this species was the last host to yield live aphids. Intermediate pubescent wheatgrass also produces relatively dense tussocks and harbored live aphids until mid-February (Table 2). In general, winter survival of parthenogenetic *D. noxia* in North America may depend on a complex interaction between climatic conditions and host type. Young winter wheat

TABLE 3. Mean daily minimum temperatures (°C) per month from October to April 1991–92 and over the previous 30 yr at Logan, Utah.

Month	Mean minimum temperature	
	1991–92	Long-term (± SD)
October	6.7	3.6 ± 1.6
November	−2.1	−2.0 ± 1.4
December	−9.1	−7.9 ± 2.4
January	−11.0	−9.3 ± 3.1
February	−3.5	−6.8 ± 3.3
March	2.3	−2.4 ± 2.4
April	5.9	2.1 ± 1.7

plants would probably provide less protection than most of the mature tussock grasses studied here.

It was anticipated that the live aphids recovered in mid-March would produce a significant infestation of grasses in the spring, since temperatures never dipped much below 0°C for the remainder of the early spring (Fig.1). The apparent extinction of the population suggests that aphids classified as alive in February and March had already suffered irreversible cold injury and were incapable of resuming feeding and development when temperatures increased. This hypothesis was also supported by the high frequency of torpid aphids in the February sample and the rapid mortality of aphids placed on wheat seedling in the laboratory. Caution is therefore required in inferring overwintering ability or in forecasting spring infestations from simple live or dead determinations. Finally, this survey supports the contention of Butts (1992) that the overwintering success of *D. noxia* cannot be predicted simply from the aphid's supercooling point of ca. −25°C. Aphids suffered complete mortality on Indian ricegrass and Snake River wheatgrass, for example, well before ambient temperature approached the supercooling value (Table 2, Fig.1). It is interesting to note that Indian ricegrass is a relatively poor overwintering host for *D. noxia* but a consistently superior summer host (Table 1, and unpublished data).

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